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Is ADHD a Stress-Related Disorder? Why Meditation Can Help

Sarina J. Grosswald

Additional information is available at the end of the chapter

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1. Introduction

ADHD is the most common neurobehavioral disorder of childhood [1]. It is also one of the most extensively studied childhood disorders. In spite of the thousands of research articles written about ADHD, a cause has not been clearly identified. Theories include genetic abnormalities, structural differences in the brain, food additives, and more. Although these factors may be physiological correlates to the symptoms of ADHD, none has been established as a cause.

Factors that have been identified to increase the risk of ADHD include premature birth, low birth weight, poor maternal health, poverty, and maternal cigarette use. While at first glance it may be difficult to find a unifying relationship among these risk factors, at a closer look all of these situations place significant physiological, and potentially psychological, stress on the developing fetus and growing child.

This chapter will consider the effects of stress on the brain, the relationship between stress and ADHD, and the use of the Transcendental Meditation (TM) technique to reduce stress and reduce the symptoms of ADHD. It will also explore the potential of the technique as a means of lowering the risk, and possibly even preventing ADHD.

2. The developing brain

ADHD is a developmental disorder causing impaired executive function, or higher order functioning of the brain. Therefore, it is important to consider how the brain develops.

At birth, a baby has almost all the neurons, or brain cells, that individual will ever have. However, there are few strong connections. It is somewhat like a pile of electrical wires with a plug and a light bulb somewhere in the pile, but few of the wires are actually connected in order to send a functioning signal from the wall socket to the light bulb. During the first two years of life there is an explosion of brain connections, sometimes referred to as “neural exuberance.” This is a critical period in brain development as the child learns from experience and the environment. By age three, the brain has formed about 1,000 trillion connections — twice as many as what is found in adulthood. A baby’s brain is very dense, and will stay that way throughout the first decade of life.

Around age 7 the brain begins actively pruning unused or little used connections. Repeated experiences create strong connections, while processes that are used only once or twice, or are inhibited during this critical period, are pruned. The connections that remain are stronger and faster.

Though the brain reaches 90-95 percent of its adult size by age six, it continues to develop in waves, with different parts of the brain developing at different times. The brain grows and specializes, expanding from governing only the simple functions like appetite, sleep, and motor activities, to developing more complex functions such as emotions, and finally, reasoning and critical thinking — the “executive functions.” Executive function is controlled by the cortex, particularly the frontal cortex, and is the last area of the brain to develop.

Roughly between the ages of 10 and 13, the frontal cortex experiences another growth spurt (Figure 1). This growth is followed by another period of pruning, particularly in the prefrontal cortex, beginning about age 12 and continuing into the early 20s. Consequently the part of the brain responsible for higher executive functions such as planning, working memory, organization, reasoning, judgment, and impulse control is undergoing major change during adolescence.

An important development during this period is the process called myelination, development of a fatty layer around the brain cell fibers which takes place during the brain’s growth spurts. Myelination increases the speed of information processing. Since the cortex is the last part of the brain to mature, myelination that connects the prefrontal cortex to the parts of the brain responsible for lower order functioning such as sensory functions, movement, and emotion does not begin to strengthen until the preteen and teen years. It is during this time that preadolescents and adolescents begin exerting independence, thinking for themselves, making their own decisions, and trying out independent reasoning.

As mentioned, this is also the time when the second period of pruning is taking place, particularly in the frontal area of the brain. Executive function is improving as the prefrontal cortex communicates more fully and effectively with other parts of the brain, including those areas that are particularly associated with planning and problem-solving, emotion, and impulses. As these connections strengthen over time, the teen may show mature, clear, lucid thinking. But as a consequence of pruning, the teen may forget these lucid thoughts the next day, and act in a more childish or impulsive way. Consequently, it is not surprising that it is

during the middle school years that these actions are often interpreted as signs of a deeper problem, and parents or teachers raise concern about ADHD.

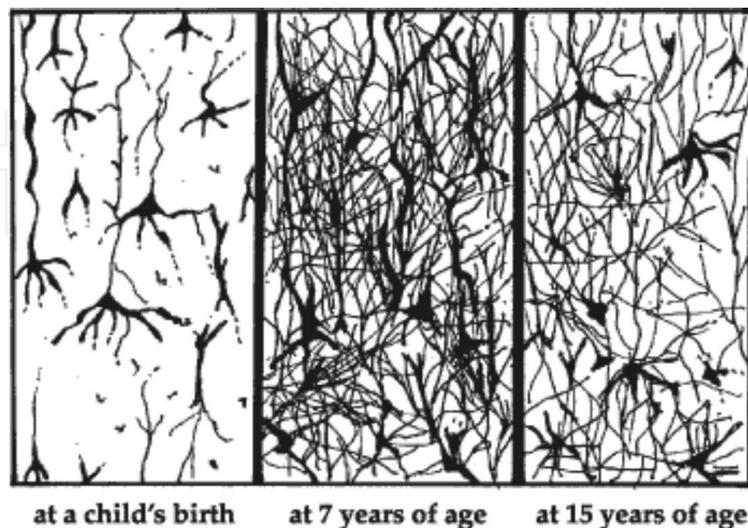


Figure 1. Density of Neuronal Connections at Different Times During Brain Development

3. Factors that negatively affect the brain

Developmental psychologists often say the "first years last forever," because this is a time of rapid development of the brain. It is a time when neurons are connecting in patterns and pathways based on the experiences to which the infant is exposed. These early experiences determine the strength and function of the brain's wiring.

Researchers have long known the importance of contact, touch and cuddling of a newborn for the child to have healthy emotional development. The "prime time" for "emotional intelligence" to develop is from birth to age 18 months. This provides the foundation for other aspects of emotional development as the child grows. The amygdala, which regulates emotion, is shaped early by experience, and forms the brain's emotional wiring. Early nurturing is important to learning empathy, happiness, hopefulness and resilience.

Traumatic events early in life, such as abuse, neglect, severe deprivation, or exposure to violence, negatively impact psychosocial development. Children who are exposed to violence and abuse at an early age tend to have both mental and physical health problems in childhood, with lasting effects in adulthood and throughout life. As they grow up, these children are more prone to aggression, conduct disorder, delinquency, antisocial behavior, anxiety, depression, and suicide [2], [3]. They are vulnerable to developing more slowly in their social and behavioral skills than their peers, or to actually getting "stuck" developmentally, perpetually acting younger than their age, consequently increasing the risk of being diagnosed with ADHD (Table 1).

Because early childhood is such a sensitive time in development, adverse influences during this time significantly increases the risk of ADHD (Table 1). For example, children whose parents divorce are almost twice as likely to be on ADHD medication after the split [2], [4]. Living with a single parent can increase the chances of a child being on ADHD medication by more than 50 percent. If a child is from a family on welfare, the likelihood of the child being on ADHD medication increases by a staggering 135 percent.

It is not only influences in the first few years that can permanently influence the growth and development of a child, but also influences during prenatal development. Studies show that when a mother drinks alcohol or takes drugs, especially early in pregnancy, it can alter the baby's brain development, reducing the number of neurons created, and affecting the way the neurotransmitters function.

Alcohol is a leading cause of the destruction of myelination in the brain. As a result of maternal alcohol abuse, the child comes into the world with neurobiological problems that include difficulties with attention, memory, problem solving, and abstract thinking – problems that will later become symptoms of ADHD.

Other aspects of the mother's health similarly influence the health of the child, and the likelihood of ADHD. Children born to mothers who have physical or mental health problems during pregnancy, including depression, anxiety, and musculoskeletal symptoms are more likely to later have ADHD [5] [6]. Similarly, if the mother experiences these problems within two years after the baby is born, the child has a higher risk of ADHD [7]. If a mother suffers from depression in the first 5 years of the child's life, the child is 2.5 times more likely to have ADHD.

Stress at birth is another factor raising the risk of ADHD. Danish researchers found that babies born prematurely have up to 70% greater risk of ADHD. Similarly, babies born of low birth weight have 50-90% greater risk of ADHD, depending on the weight at birth [8]. Babies born prematurely who are exposed to prenatal smoking can have smaller frontal and cerebellar areas of the brain, which are responsible for executive function and motor coordination, respectively. Children of mothers who smoke more than a pack of cigarettes a day are two and a half times more likely to later be taking medication for ADHD.

4. Effects of stress on the brain

Chronic physical or psychological stress can change the brain. The body's natural response to stress is to activate the sympathetic nervous system and hypothalamic-pituitary-adrenal (HPA) axis, leading to an increase in levels of catecholamines, corticotropin, and cortisol, creating the fight-or-flight response. Adrenaline and then cortisol are secreted by the adrenal glands, revving up the body, then sustaining energy flow to different systems. The lungs pump faster, and the heart begins to race. Blood pressure rises, stimulating muscles and sharpening the mind to a singular focus of attention. The release of endorphins numbs the body. Appetite, libido, and the immune system shut down. Energy normally directed to these functions is

Premature birth	70% increased risk
Low birth weight (3-5 lbs)	90% increased risk
Low birth weight (5-6 lbs)	50% increased risk
Mother's depression in child's first 5 years	2.5 times higher risk
Living with single parent	50% increased risk
Maternal smoking	2.5 times more likely to be on ADHD medication
Poverty	135% increased risk

Table 1. Factors that Increase the Risk of ADHD

redirected to the muscles. The response is intended to help the person react quickly and effectively to a high-pressure situation (i.e., fight or flee).

In a normal stress response, the autonomic nervous system, the HPA axis, and the cardiovascular, metabolic, and immune systems protect the body by responding to internal and external stress, then return to a balanced state.

However, chronic acute stress impairs the body's ability to return to allostasis, or baseline, leading to an out of balance biochemistry, with elevated cortisol and suppressed serotonin. Excessive levels of cortisol in the brain impair the function of the hippocampus, leading to neuronal atrophy and destruction of neurons, decreased short term and contextual memory, and poor regulation of the endocrine response to stress.

Prolonged stress hinders the body's ability to tell the hypothalamus to stop calling for more stress hormones. As a result, stress hormones flood the bloodstream, causing additional damage to the hippocampus, and additional stress. The price can be allostatic load, which is the wear and tear that results from chronic overactivity or underactivity of allostatic systems [9], [10].

The increase in cortisol inhibits utilization of blood sugar by the hippocampus, the brain's primary memory center. Reduced glucose produces an energy shortage, and the brain has no way to imprint memories. This results in the immediate short-term memory problems that are associated with stress. Further, cortisol overproduction interferes with the brain's neurotransmitters, making it hard to retrieve stored memories. Too much cortisol disrupts normal brain cell metabolism, eventually producing free radicals, which kill brain cells.

An increase in cortisol leads to a decrease in serotonin. Serotonin is a critical stress hormone, influencing body temperature, blood pressure, pain, digestion, sleep, and circadian rhythms. Deficiency in serotonin leads to behavioral concerns such as increases in irritability, aggression, impulsivity, suicide, and alcohol and drug abuse.

Chronic stress damages or kills neuronal connections. As much as 34% reduction in cells in the prefrontal cortex have been reported [11]. Significantly, chronic stress results in lower levels

of expression of genes required for the function and structure of brain synapses [12]. Researchers found that a single transcription factor called GATA1, present with chronic stress, represses the expression of several genes that are necessary to form synaptic connections between brain cells in the prefrontal cortex (Figure 2).

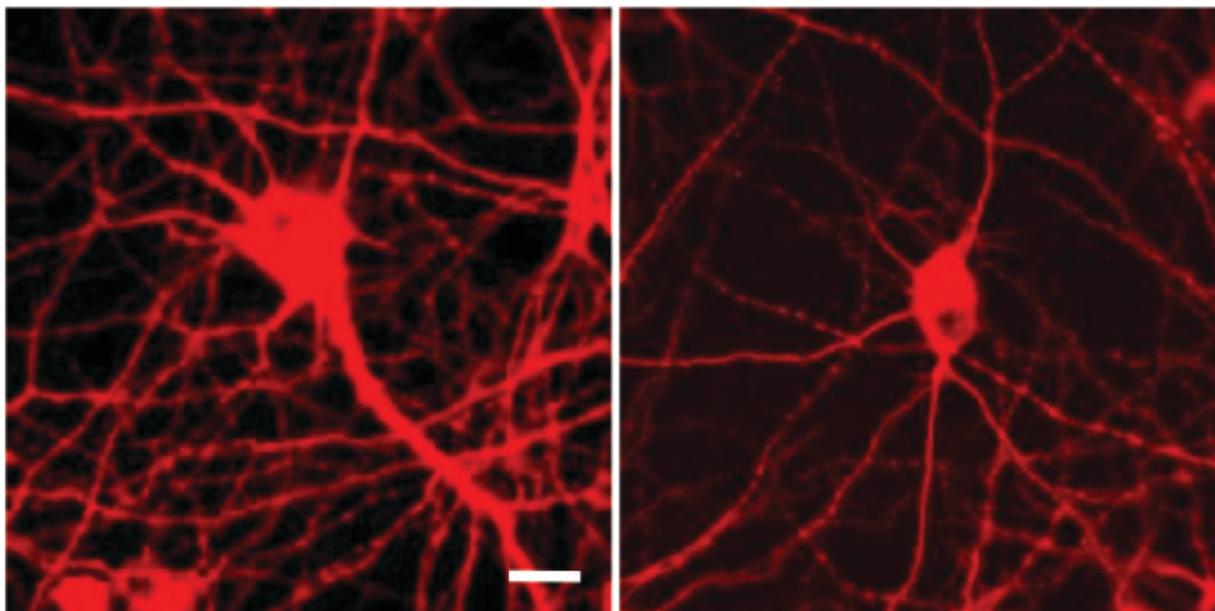


Figure 2. Tissue sample on the left from the prefrontal cortex of a Control subject. Tissue on the right, from a subject with depressive disorder shows dramatic reduction in prefrontal cortical synapses. (Figure courtesy of Kang, et al.)

5. Relationship between stress and ADHD

Disruptions of the neuronal connections in the prefrontal cortex caused by stress, interferes with executive function and behavior regulation [9]. Stress-impaired executive function is associated with impaired working memory, impaired impulse control, and lack of mental flexibility and coping strategies. Stress also dramatically compromises selective attention and the ability to sustain attention [10].

ADHD is associated with impaired executive function, specifically brain circuitry governing behavior [13], [14], [15]. Dysfunction of these circuits leads to impulsivity and lack of normal social inhibition, as well as impaired working memory, inability to focus attention, and impaired temporal organization.

In light of these similarities, the connection between stress and the symptoms of ADHD begins to emerge. Stress negatively affects brain function, resulting in the same symptoms associated with ADHD. Table 2 compares symptoms of stress identified by the US Centers for Disease Control and Prevention, and diagnostic factors for ADHD as defined by the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). The symptoms are nearly parallel. In fact it

can be said that the differences are simply the difference in the way the symptom might be expressed in an adult compared to a child.

Symptoms of Stress	Symptoms of ADHD
Inability to concentrate	Difficulty sustaining attention
	Not listening when spoken to
Difficulty organizing	Difficulty organizing
Memory problems	Forgetfulness
Poor judgment	Speaks without thinking
Short temper	Impulsivity

Table 2. Symptoms of stress closely match symptoms of ADHD

Recent research sheds further light on the relationship between stress and ADHD. Vance, et al., demonstrated dysfunction of the right prefrontal regions of the brain in ADHD children [16]. This region is responsible for developing coping strategies, influencing the ability to handle stress. Early experiences of stress are believed to affect the level of responsiveness of the HPA axis and autonomic nervous system.

Young children exposed to chronic stress, can become overly accustomed to dealing with fear states, becoming conditioned to having or tolerating higher levels of adrenaline. Chronic acute stress damages the body's ability to return to non-stress levels, leading to chronically elevated levels of cortisol, a biochemical marker of stress. In children with ADHD high cortisol levels impair executive function, self-regulation, and letter knowledge [17].

Dysregulation of the central noradrenergic pathways in the brain is believed to underlie the pathophysiology of ADHD [18]. The noradrenergic system is associated with the modulation of attention, alertness, vigilance and executive function. Specifically, dopamine is associated with behavior and impulsive control, while norepinephrine is associated with focus, planning, and concept thinking including sequence and time. Disruption of the noradrenergic function seen in the presence of the “fight-or-flight” response involves the same neurochemistry associated in ADHD. In fact, the majority of ADHD medication involves increasing the presence of dopamine, norepinephrine, and serotonin.

6. The transcendental meditation technique

Given the role stress seems to play in the symptoms of ADHD, it is logical to explore stress reduction techniques, such as meditation, as a means of minimizing the effects of stress and reducing the related symptoms associated with ADHD.

There are many systems of meditation. Techniques differ widely from one another in their procedures, content, beliefs, and goals. Each technique uses a different process and thus has different effects [19], [20].

With advances in neuroscience, the study of meditation has become more specific and more evidence based. Most recently, using EEG signatures and the corresponding cognitive processes, meditation practices have been classified into three types: focused attention, open monitoring, and automatic self-transcending [21].

Techniques of focused attention are concentration techniques, and are associated with voluntary sustained control of attention on the object of meditation, such as an event, image, or sound. The brain activity during concentration meditations is characterized by EEG in the beta-2 (20-30 Hz) and gamma (30-50 Hz) frequency bands. Open monitoring or mindfulness-based techniques, involve dispassionate non-evaluative monitoring of ongoing experience. These techniques are characterized by frontal theta (5-8 Hz) EEG, and perhaps occipital gamma (30-50 Hz) EEG. Automatic self-transcending meditation is defined as effortless transcending of the meditation process itself [22], [21]. EEG activity of an automatic self-transcending technique is associated with alpha-1 (7-9 Hz), characteristic of reduced mental activity and relaxation.

The Transcendental Meditation technique falls into the category of automatic self-transcending. Concentration and open monitoring meditations both require some mental effort (i.e., holding attention on its object or maintaining attention on an ongoing experience, respectively). The Transcendental Meditation technique automatically leads to the experience of "consciousness itself," awareness without any objects of awareness, a low-stress state called transcendental or pure consciousness [23].

Practice of the technique is not based on concentrative effort, contemplation, prayer, or deliberate attempts to make the awareness more mindful or alert. Rather, the technique allows the conscious awareness, or active thinking, to spontaneously "transcend" to deeper, quieter levels of the thinking process, eventually experiencing the most settled state of awareness, where the mind is fully awake within itself, without experiencing objects of perception.

The Transcendental Meditation technique is a mental technique practiced for 10-20 minutes twice each day, sitting in a chair with eyes closed. It is easy to learn and to practice. Because it does not require concentration or controlling the mind, it is particularly well suited for children or adults with ADHD.

The technique is taught by certified Transcendental Meditation teachers in a 7-Step course. The 7-Step course of instruction involves two informational lectures (Steps 1 and 2), a brief interview with the TM instructor (Step 3), individual personal instruction (Step 4), which is followed by three days of verification of practice and additional information (Steps 5-7). The interview is about 10 minutes, while the remaining steps are approximately 1-1.5 hr each day. Each step can be conducted in a group except Steps 3 and 4, which are conducted individually, one-on-one. Periodic meetings with the student assure correct practice and reinforce regularity of the practice.

During the course of instruction, the student learns how to let the mind move from active focused levels of thinking to silent, expanded levels of wakefulness at the source of thought, without concentration or effort [24] (Figure 3).

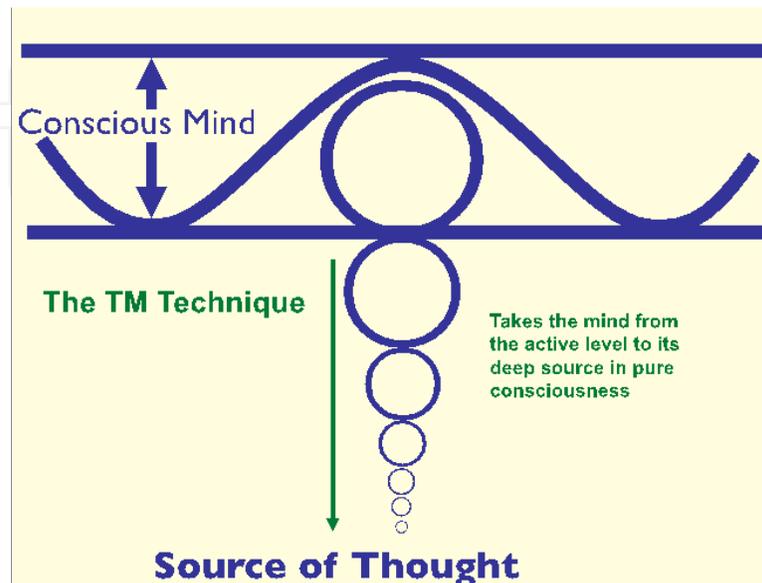


Figure 3. During the Transcendental Meditation technique the mind moves from the active, directed thinking level to the more subtle levels of thinking, to eventually go beyond the boundaries of thought to experience 'pure' consciousness.

Regular practice of the technique creates a state referred to as "restful alertness." The term reflects a combination of markedly decreased metabolism, heart rate, respiration rate, and blood flow to the limbs, similar to deep rest or sleep; while at the same time mental alertness is maintained, as demonstrated by EEG [25], [26], [27]. The TM technique produces a significantly greater degree of deep rest than sitting with eyes closed, measured by reduced respiration, reduced skin conductance (increased skin resistance), reduced plasma lactate [25], more rapid recovery from stressful stimulus, and leads to a reversal of symptomatology associated with severe and chronic stress [28].

Meta-analyses indicate that the Transcendental Meditation technique is two to four times more effective in reducing stress and anxiety than other meditation or relaxation techniques [19]. A 2012 meta-analysis found Transcendental Meditation to be the most effective technique across a broad spectrum of psychological and cognitive variables including negative emotions, neuroticism, perception, trait anxiety, behavior, and memory and learning [29] (Figure 4).

Measurements of brain function show increases in brain coherence both during the practice of the Transcendental Meditation technique, and afterwards in activity [21], [30], [31]. The primary areas of the brain that are activated are the frontal and prefrontal executive areas responsible for attention, executive function, emotional stability, and anxiety (Figure 5) [32], [31], [33], [34]. Study of college students demonstrated increased frontal coherence and reduced stress reactivity in the group practicing the Transcendental Meditation technique

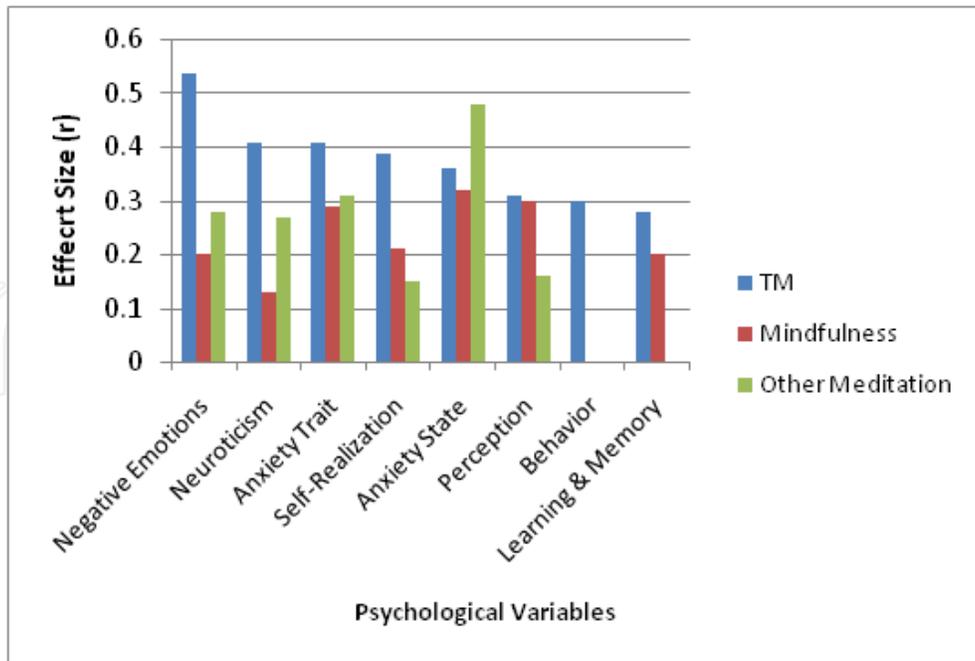


Figure 4. Meta-analysis of 163 studies of various meditation techniques, comparing the effects on psychological variables [29].

compared to controls [35], [36]. Further, students in the TM group showed that TM may lead to a foundational or ‘ground’ state of cerebral functioning and more focused cognitive processes [36].

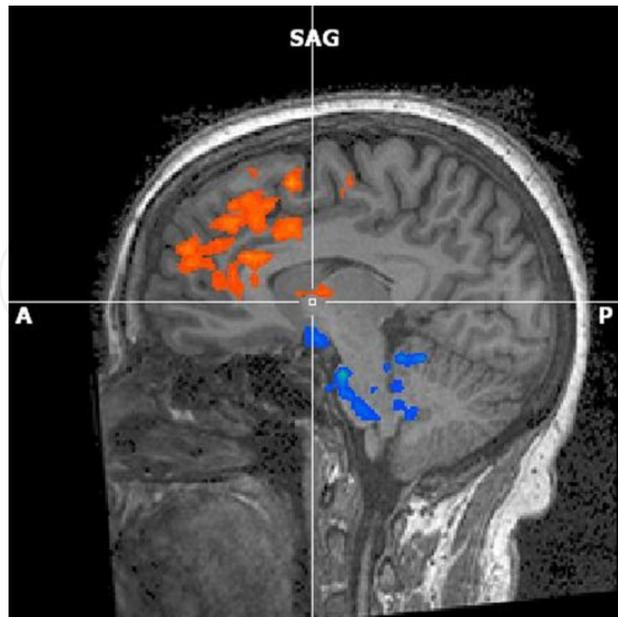


Figure 5. fMRI showing increased activation in the frontal areas of the brain during the practice of the Transcendental Meditation technique (Courtesy of M. Ludwig)

The effects of the Transcendental Meditation technique extend to the noradrenergic networks [26], [37], [38], resulting in a decrease in the stress hormone cortisol, both during meditation and continuing outside meditation, during activity. Practice of the technique increases serotonin availability, improving mood and reducing the activation of the brain centers for fear, anxiety, and anger.

The use of the TM technique for stress reduction in adolescents has resulted in improvement in school behavior, decreases in absenteeism and rule infractions, and reduction in suspensions due to behavior-related problems [39]. Students practicing the TM technique show higher performance on scales of self-actualization [40], increased emotional regulation, and improved well-being [41] as well as improved academic performance.

7. The Transcendental Meditation technique and ADHD

The Transcendental Meditation technique creates a neurobiological response opposite to that induced by stress. It enlivens the executive areas of the brain, and is associated with improved psychosocial behavior in normal populations.

Studies of the TM technique with students with ADHD demonstrate that the benefits of the technique also extend to this population. A 3-month pilot study was conducted with children ages 11 to 14 with the diagnosis of ADHD, and in some cases comorbidities, including general anxiety disorder, dysthymia, obsessive compulsive disorder, pervasive developmental disorder, sleep disorders, and tics [42]. These children also had language-based learning disabilities. The study measured effects of the Transcendental Meditation technique on stress, anxiety, and ADHD symptoms; and measured changes in executive function. Measures of stress and ADHD symptoms included the Achenbach Child Behavior Checklist (CBCL) completed by parents and teachers, the companion inventory the Achenbach Youth Self-Report (YSR), and the Revised Children's Manifest Anxiety Scale (RCMAS). Measures of executive function included the Behavior Rating Inventory of Executive Function (BRIEF), the Cognitive Assessment System (CAS) Expressive Attention, Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency test, and Connor's CPT II.

After three months, there were highly statistically significant reductions in anxiety and anxiousness, depression symptoms, attention problems, and total problems (Table 3).

Statistically significant improvements in executive function as measured by the BRIEF showed improved Behavioral Regulation (includes ability to Inhibit, Shift for one task to another, and Emotional Control). Similar improvements were seen in the Metacognition Index (includes ability to Initiate, Working Memory, Planning, Organize Material, and Monitoring).

A second study, a randomized control trial of a similar population as the previous study, explored improvements in brain coherence and brain development [43]. The purpose was to provide insight into the underlying mechanisms of observed changes. The study measured EEG coherence, theta/beta ratio, and executive function.

	Student					Teacher				
	Pretest		Post Test			Pretest		Post Test		
Symptom	Mean	SD	Mean	SD	ES	Mean	SD	Mean	SD	ES
Anxious/ Depressed	5.7	3.6	2.7*	3.7	.8	10.2	6.4	5.6*	3.6	.7
Withdrawn/ Depressed	4.8	2.7	3.9**	3.0	.3	4.3	3.8	3.6	4.0	.2
Affective Problems	5.8	3.4	4.1*	2.5	.5	5.0	3.7	3.6	3.6	.4
Anxiety Problems	3.2	2.0	1.6**	1.9	.8	3.7	3.5	2.1	2.4	.5
Attention Problems	7.0	4.0	5.2*	3.5	.5	23.6	10.5	22	11.0	.2
ADHD Problems	5.4	2.9	4.3	2.7	.4	12.4	5.7	11.7	5.7	.3
Total Problems	52.5	25.6	40*	27.4	.5	63.1	24.8	56*	31.2	.3

* $p \leq .05$. ** $p < .005$ ES=Effect Size

Table 3. Results of Achenbach Child Behavior Checklist and Youth Self Report after three months practice of the Transcendental Meditation technique among children with ADHD.

EEG of ADHD populations show decreased activation in parietal areas of the brain that weave sensory input into concrete perception [44], higher density and amplitude of theta activity [45], [46], and lower density and amplitude of alpha and beta activity [47]. Theta is thought to block out irrelevant stimuli during memory processing. In ADHD subjects, greater theta activity may block out relevant as well as irrelevant information. Theta/beta ratios are highly correlated with severity of ADHD symptoms.

Another brain marker of ADHD is EEG coherence, a measure that reflects the number and strength of connections between different brain areas. In children diagnosed with ADHD, coherence in all frequencies is lower [48]. Alpha coherence is thought to play an important role in attention.

In the TM study, EEG of ADHD students was taken during a computer-administered paired choice reaction-time task to calculate theta/beta ratios and patterns of EEG coherence. The study also applied several of the same measures of executive function used in the previous study. At pretest, all students showed theta/beta ratios well above the normal range (normal average=3). Subjects were randomly assigned to the TM group and delayed-start group. The delayed-start group served as controls for the first three months, then also learned the TM technique.

Coherence maps were calculated at pretest, 3 months, and 6 months. At 3 months, from pretest to posttests compared the TM group to the control group. At six months, changes in coherence for the control group (delayed start, who had been meditating for 3 months) were calculated from 3-month to 6-month posttests. The resulting maps showed present

coherence in theta (5.0-7.5 Hz), alpha (8.0-12 Hz), beta1 (13-20 Hz), and gamma bands (20.5-50 Hz).

Results (Figure 6) indicated few sensors with higher coherence in the delayed-start group at the 3-month posttest compared to their pretest values. In contrast, in the TM group there were many frontal and parietal areas at 3-month posttest compared to pretest values. At 6-month posttest, the delayed start group (who learned TM at 3 months) also showed many frontal and parietal areas with higher coherence compared to the 3-month posttest values.

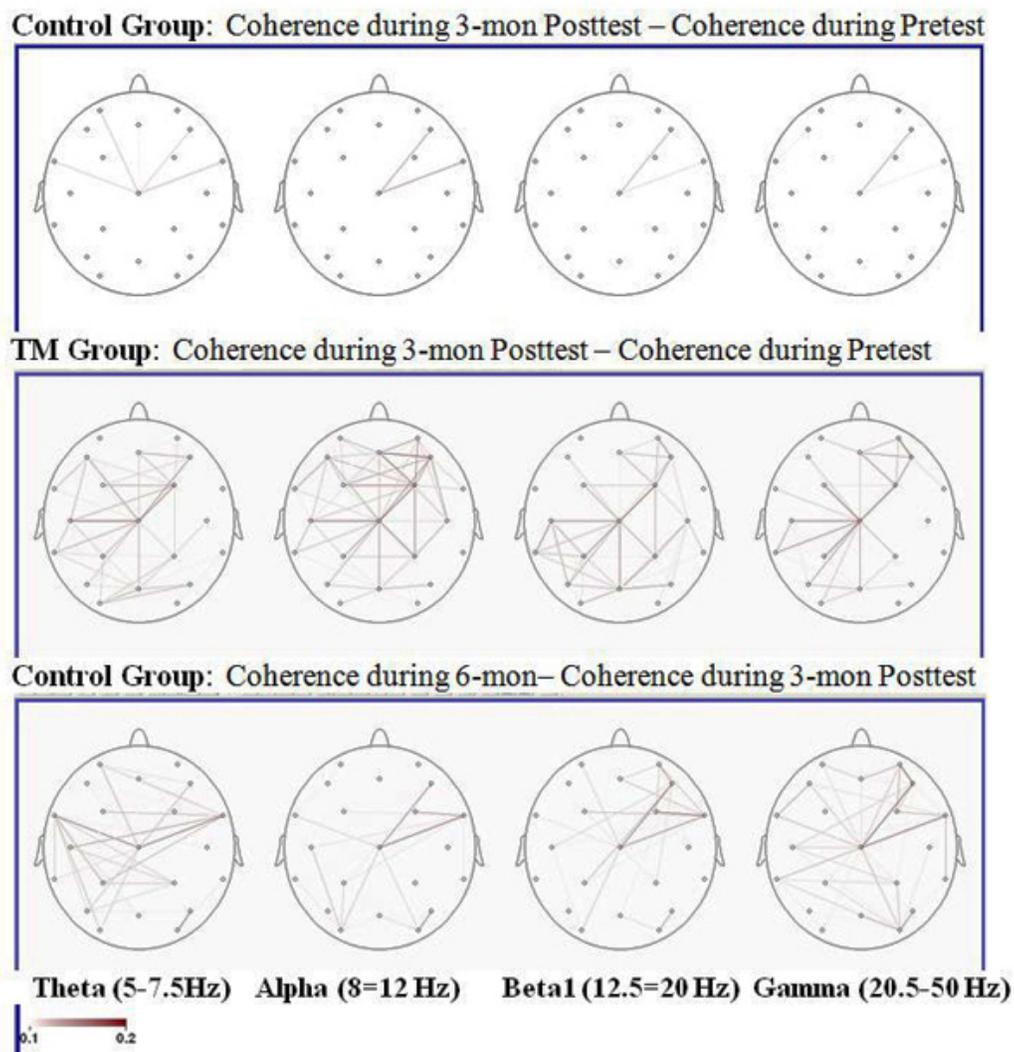


Figure 6. Coherence maps of at baseline, 3-months, and 6-months among children with ADHD. Top row is coherence during the 3-month posttest minus baseline coherence for the delayed-start subjects. Middle row is coherence during the 3-month posttest minus baseline coherence for the TM subjects. Bottom row is coherence during the 6-month posttest minus 3-month posttest for the delayed-start subjects, who had been meditating over this time.

At the 3-month posttest, theta/beta ratios increased in the delayed-start group, which is opposite to the desired effect, while the TM subjects moved closer to normal values. At the 6-month posttest, after both groups were practicing the TM technique, theta/beta ratios de-

creased in both groups. For the delayed start group, theta/beta ratios also significantly decreased from the 3-month to 6-month posttest after three months practice of the TM technique (Figure 7).

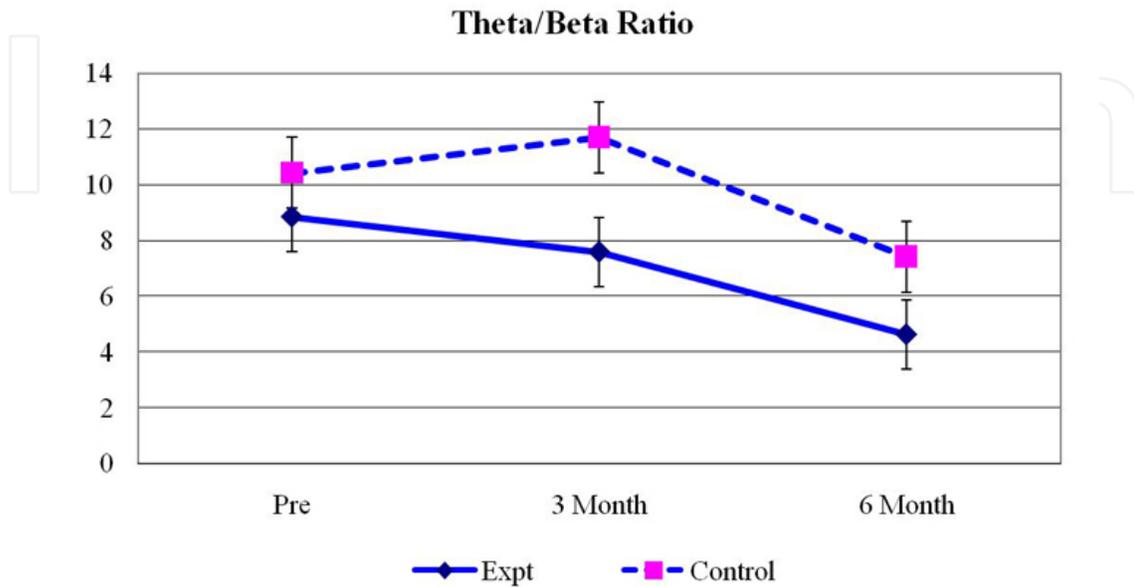


Figure 7. Theta/beta ratios compare results at pretest, 3-month and 6-month posttests. Transcendental Meditation group showed reductions at 3-months compared to delayed start controls. TM group showed continued improvements at six months. Delayed start showed significant improvements from 3-months to 6-months, after meditating for 3 months.

8. Prevention

An initial literature search of research on preventing ADHD turns up no significant contribution to the subject of effecting the underlying causes. In fact, it seems to be an area that is not actively being addressed. Most research on prevention is focused on preventing of other social problems that arise among children with ADHD, such as smoking or criminal behavior.

Without an understanding of the disorder's etiology, prevention cannot be addressed. The etiology currently gaining most attention is genetic causes. However, genetic alterations associated with ADHD may be a correlate rather than a cause. As discussed earlier, chronic stress can result in changing gene expression, resulting in structural impairment of the prefrontal cortex.

Considering the factors discussed in this chapter, a unifying underlying cause emerges. Chronic stress, whether physical or emotional, can result in structural impairment to brain, and give rise to the symptoms identified as ADHD.

Recognition of the role stress plays in ADHD offers an opportunity to intervene to alter the course of the disorder. Some risk factors such as maternal smoking can be addressed through education and public health efforts, a child's risk of developing ADHD. Other causes of stress, however, may be more difficult to avoid or eliminate (e.g., premature birth, poverty). But many of the stress factors that raise the risk of ADHD are known (Table 1), therefore, interventions that immediately address reducing the effects of the stressors, have the potential of reducing the damaging effects on the brain, and possibly avoid development of the symptoms of ADHD.

When a child, or even an adult, begins to show signs of difficulty with attention and focus, disorganization, behavior issues, and difficulty controlling anger or impulses, a thorough approach to diagnosis should include assessment of potential causative factors. In as many as 75- 85% of cases, ADHD is complicated by the presence of other emotional or behavioral disorders [49]. Treating the underlying disorder can result in reduction of ADHD symptoms.

If the symptoms arise as a child enters school, an evaluation of learning can be useful. Approximately 20-30% of children with ADHD also have a learning disability [50]. When a child starts to show difficulty academically, he or she tends to lose interest in learning, can become easily distracted, or may engage in disruptive behaviour. This can lead to a diagnosis of ADHD since these are also clinical symptoms of the disorder. However, they may actually be caused by a learning problem, whether it is a learning disorder or simply the consequence of getting behind or confused in an academic subject and unable to catch up. An educational assessment can help distinguish the underlying problem.

If symptoms arise when a child changes schools or environments, this can be an underlying cause of stress, and consequently the appearance of ADHD related problems. Traumatic events such as conflict at home, or loss or separation from parents or close caregivers can result in ADHD symptoms.

Children who are exposed to geopolitical violence or natural disasters often display symptoms interpreted as ADHD, when they may actually be stress responses to the trauma or the chronic stress of living in fear. Each year in the US, more than five million children are exposed to some form of extreme traumatic stressor. These traumatic events include natural disasters such as tornados, floods, hurricanes; motor vehicle accidents; life threatening illness and associated painful experiences such as cancer or burns; or witnessing violence in the home or community. Over 30 percent of these traumatized children develop a clinical syndrome with emotional, behavioral, cognitive, social and physical symptoms significant enough to be diagnosed with post traumatic disorder (PTSD). Some of the symptoms of PTSD are very similar to those of ADHD. Without an exploration of the underlying causes of ADHD symptoms, other problems may go undiagnosed.

Regardless of the underlying cause of the stress, the Transcendental Meditation technique can provide an intervention that can reduce the effects of stress and related symptoms, including symptoms that might be diagnosed as ADHD.

For children as young as four or five years old, the Transcendental Meditation technique has been shown to effectively reduce stress and increase cognitive development. It can balance neurochemistry, reversing the cycle of high cortisol leading to low serotonin; thus improving

mood and impulse control. (Note: for children below the age of 10 years old, the technique is slightly different, done with the eyes open, while engaged in non-focused activity.) The technique also leads to balancing dopamine and norepinephrine, the same neurotransmitters that are the target of common ADHD drugs.

For children younger than four years old, who may be too young to learn the TM technique, the Maharishi Ayurveda Mother and Baby Program provides dietary and behavioral guidelines that include foods cooked according to specific principles, and Ayurvedic massage that reduces stress and improves the baby's sleep and digestion [51]. When this approach is incorporated for the mother and the baby, along with the mother's practice of the Transcendental Meditation technique, it improves the mother's mental and physical health, and leads to a better start for the baby.

9. Case study

The following case study will illustrate how the concepts presented in this chapter can affect an individual child. At the first introduction to Jessie (not his real name), he was 7 years old and had just been diagnosed with ADHD. His mother explained, "He can't control his emotions - happy or sad emotions. He can be extreme in either direction." She described that sometimes he would be in such a rage, that he would hide under his bed or go out to his father's car to try to calm himself. "I'm afraid one day he'll be standing over me with a knife. I don't know what to do," she said. He was also having difficulty with attention and behaviour at school.

Jessie seemed like a very sweet, though rambunctious, boy. He did not seem to display any malice or meanness, but if he got frustrated or over-excited, he could not control his emotions. He was from a warm and loving family with both parents and a younger brother. They had a warm, healthy home life, and there did not seem to be cause for the level of stress that might lead to the behavior Jessie would sometimes exhibit.

Discussion with Jessie's mother, however, shed light on the situation. She had two miscarriages before Jessie was born. As a result she was very anxious during her pregnancy with Jessie. After he was born, she had another miscarriage, which led to depression and medication for her depression. When she became pregnant again, she had complications requiring bedrest for the last trimester, making it difficult to give full attention to Jessie.

During the time 2-year old Jessie's mother was in the hospital giving birth to his brother, Jessie stayed with his grandmother. While there, he got sick, requiring hospitalization, where he was temporarily put on oxygen. One can imagine how scary this would be for a young child, and though his father was with him, his mother was not.

Jessie's situation was not serious, and he was not hospitalized long. However the newborn had complications, which was finally diagnosed a year later as a digestive disease. This resulted in much attention and worry around the newborn, which to young Jessie may have seemed like a form of abandonment, creating greater stress for him. While any of these

individual situations may not have caused emotional stress for Jessie, combined over an extended period of time, likely caused a significant physiological response to chronic stress. Consequently, the effect of the early adversity, several of which are known to increase the risk of ADHD, may explain Jessie's symptoms and lack of self-control, which were diagnosed as ADHD.

Jessie's parents did not want to put him on medication, so they sought another approach. At age seven, Jessie and his whole family – parents and 5-year-old brother – learned the Transcendental Meditation technique. The boys learned the young child's technique called the Word of Wisdom.

Jessie found it effective in calming himself down. It also resulted in immediate improvements in school. The next week after learning TM, he completed his weekly math test for the first time all year. He was able to maintain his attention, focus, and easily get through the task. When he turned 10 years old, Jessie learned the sitting, eyes closed technique. He does well in school, is better able to control his emotions, and gets along well with his younger brother.

Jessie eventually added a low dose of ADHD medication to augment the benefits of the meditation. He is a happy, well-adjusted child who does well in school. However, given the extreme behaviors he displayed at a younger age, his life could have quickly taken a different course. One could foresee significant behavior problems, the potential for strong life-long medication, poor success in school, and a more troubled life for him and his family. Though it is impossible to predict what would have happened over time, the value of early intervention with an effective technique for reducing stress, balancing the neurochemistry, and improving executive function can be appreciated.

10. Conclusion

A child or adult affected by trauma or severe stress loses the ability to return to a balanced state, consequently creating a cycle of chronic stress. Chronic stress alters the biochemistry and neuronal development particularly in the prefrontal cortex. The result is impaired executive function, creating lack of control of attention, focus, memory, organization, and impulses, displaying as symptoms of ADHD.

Early recognition of factors that cause severe or traumatic stress, and early intervention can help mitigate the effects. The Transcendental Meditation technique has been shown to be effective in reducing temporal and chronic stress, reducing ADHD symptoms, and improving executive function. The technique is easy to learn and easy to practice, is appropriate for people of all ages - children as young as four or five years old to adults of any age. In the presence of ADHD risk factors, the Transcendental Meditation technique offers potential for preventing full manifestation of symptoms, and provides a field for study of ADHD prevention.

Author details

Sarina J. Grosswald

Address all correspondence to: Sarina@grosswald.com

SJ Grosswald & Associates, USA

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